Tutorial 2

Topic: Application Layer Exercises

Computer & Communication Networks

Exercise 1: RTT and transmission rate

Assume that two systems at the edges of the network have a Round Trip Time (RTT) of 100 ms, and that the sender transmits 5 packets during each RTT. What is the sender's transmission rate for this RTT, assuming packets of 1500 bytes? Give your answer in bytes/sec.

Exercise 1: RTT and transmission rate

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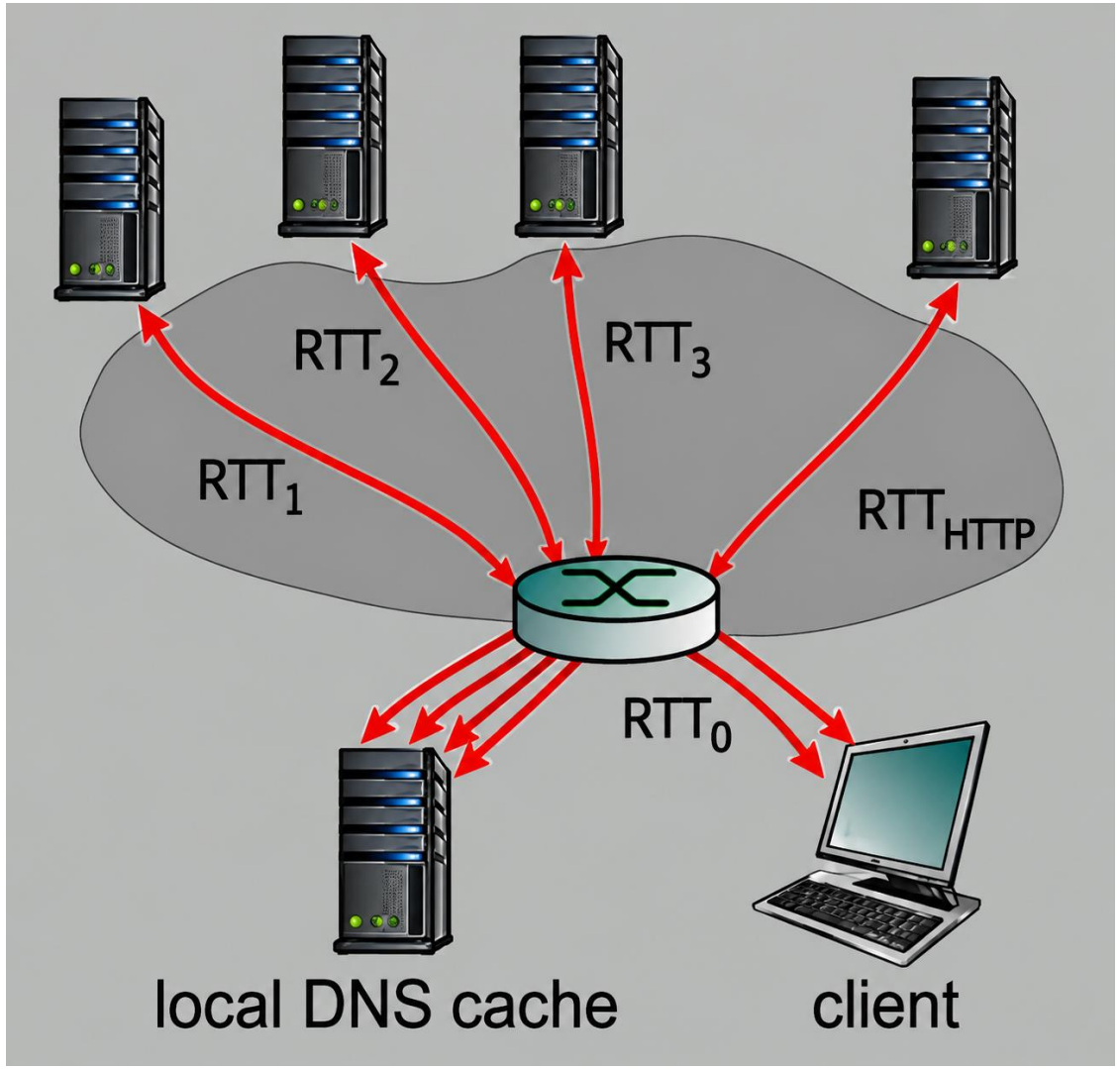
The sender transmits 5 packets of 1500 bytes every 100 ms, therefore the transmission rate is:

$$5 \times 1500 \text{ bytes} / 100 \times 10^{-3} \text{ sec} = 75000 \text{ bytes/sec.}$$

Exercise 2: DNS Lookup and HTTP Delay

Suppose that you click on a url, while browsing the WWW. The IP address of the Web Server hosting this URL is not cached on your machine, so a DNS lookup is required in order to obtain the IP address. Assume that four DNS Servers need to be queried before your machine receives the requested IP address from the DNS. The first DNS Server is the local DNS cache and introduces a Round-Trip-Time (RTT) delay of RTT_0=5 ms. The second, third and fourth DNS Servers that are queried have RTTs of 31 ms, 42 ms, and 7 ms, respectively. Assume that the Web page requested by clicking on the url contains only HTML text, and that the RTT between our machine and the Web Server is RTT_{HTTP}=62 ms.

Exercise 2: DNS Lookup and HTTP Delay



Exercise 2: DNS Lookup and HTTP Delay

Answer the following questions:

i. Assuming that the transmission time of the HTML file is negligible, how much time passes from the moment you click on the URL until the browser receives the file?

ii. Now suppose that the HTML page “contains” 9 small objects hosted on the same server. Assuming that transmission times are negligible, how much time passes from the moment you click on the page URL until all the contents of the page have been received by the browser, assuming that HTTP is non-persistent and no parallel TCP connections are used?

iii. Same as (ii), but the client is configured to support at most 5 parallel TCP connections using non-persistent HTTP.

iv. Same as (ii), but the client is configured to support at most 5 parallel TCP connections using persistent HTTP.

v. What do you observe about the total delay, comparatively, in the above cases?

Exercise 2: DNS Lookup and HTTP Delay

i. Assuming that the transmission time of the HTML file is negligible, how much time passes from the moment you click on the URL until the browser receives the file?

The total time from the moment the page is requested until the browser receives it is:

$RTT_0 + RTT_1 + RTT_2 + RTT_3 + 2*RTT_{HTTP} = 5 + 31 + 42 + 7 + 2*62 = 209$ ms

Two RTT_{HTTP} are required:

- 1 RTT_{HTTP} to establish the TCP connection, and
- 1 RTT_{HTTP} for the HTTP GET/response communication over the TCP connection

Exercise 2: DNS Lookup and HTTP Delay

ii. Now suppose that the HTML page "contains" 9 small objects hosted on the same server. Assuming that transmission times are negligible, how much time passes from the moment you click on the page URL until all the contents of the page have been received by the browser, assuming that HTTP is non-persistent and no parallel TCP connections are used?

The total time from the moment the page is requested until the browser receives the page together with all its objects is:

$RTT_0+RTT_1+RTT_2+RTT_3+2*RTT_{HTTP}+2*9*RTT_{HTTP}= 5 + 31 + 42 + 7 + 2*62 + 2*9*62 = 1325$ ms

As in (i), 2 RTT_{HTTP} are required to receive the base HTML file. Then for each of the 9 embedded objects, downloaded sequentially, an additional delay of 2 RTT_{HTTP} is required.

Exercise 2: DNS Lookup and HTTP Delay

iii. Same as (ii), but the client is configured to support at most 5 parallel TCP connections using non-persistent HTTP.

The total time is:

$RTT_0 + RTT_1 + RTT_2 + RTT_3 + 2*RTT_{HTTP} + 2*RTT_{HTTP} + 2*RTT_{HTTP} = 5 + 31 + 42 + 7 + 2*62 + 2*62 + 2*62 = 457$ ms

The delay up to the reception of the base HTML file is the same as in (ii). After that, we can have up to 5 parallel connections, receiving one embedded object through each connection. Each parallel connection requires two RTT_{HTTP}: one for the establishment of the TCP connection, and one for the HTTP GET/response communication for one object over that TCP connection. Therefore, the 9 objects are received in two groups: 5 objects in parallel and the remaining 4 objects in parallel.

Exercise 2: DNS Lookup and HTTP Delay

iv. Same as (ii), but the client is configured to support at most 5 parallel TCP connections using persistent HTTP.

The total time is:

$RTT_0 + RTT_1 + RTT_2 + RTT_3 + 2*RTT_{HTTP} + RTT_{HTTP} + RTT_{HTTP} = 5 + 31 + 42 + 7 + 2*62 + 62 + 62 = 333$ ms

The delay until the base HTML file is received is the same as in (ii) and (iii). With persistent HTTP, the TCP connection remains active for future HTTP requests, so there is no additional delay for establishing a new TCP connection. Since up to 5 parallel connections are supported, 1 RTT_{HTTP} is required for the first 5 objects and another 1 RTT_{HTTP} is required for the remaining 4 objects, using the already active TCP connections.

Exercise 2: DNS Lookup and HTTP Delay

v. What do you observe about the total delay, comparatively, in the above cases?

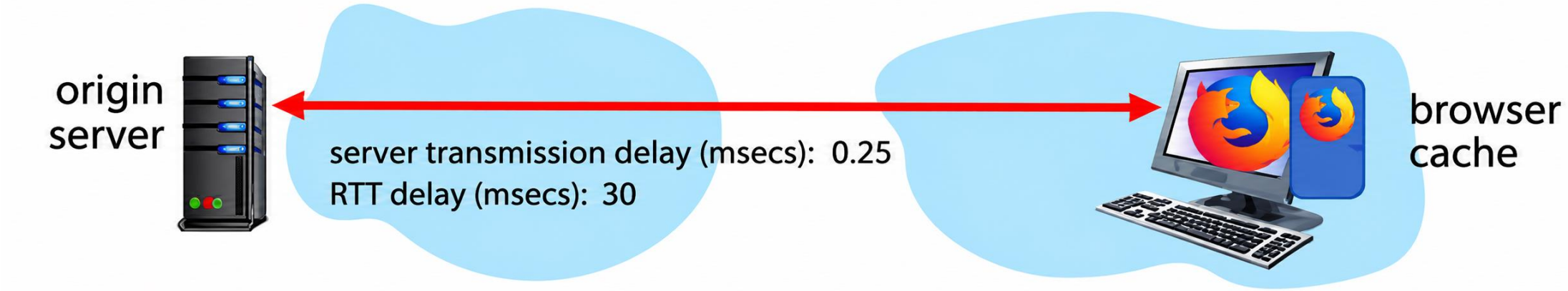
The total delay is:

- larger in (ii), where there are no parallel connections,
- smaller in (iii), where parallel connections are supported,
- even smaller in (iv), where the connections are both persistent and parallel

Exercise 3: Browser Caching

Consider the following communication between an HTTP server and a browser (client). Assume that the RTT delay between the client and server is RTT=30 ms, the time required by the server to transmit one object onto its outgoing link is 0.25 ms, and any HTTP message that does not contain an object has negligible transmission time. Assume that the client sends 100 requests again, one after another, waiting for the reply to each request before sending the next request. Assume that the client uses HTTP/1.1 and the IF-MODIFIED-SINCE header field. Assume that 50% of the objects requested by the client have NOT changed since the client previously downloaded them. How much time passes from the moment the client sends the first request until the completion of the final request?

Exercise 3: Browser Caching

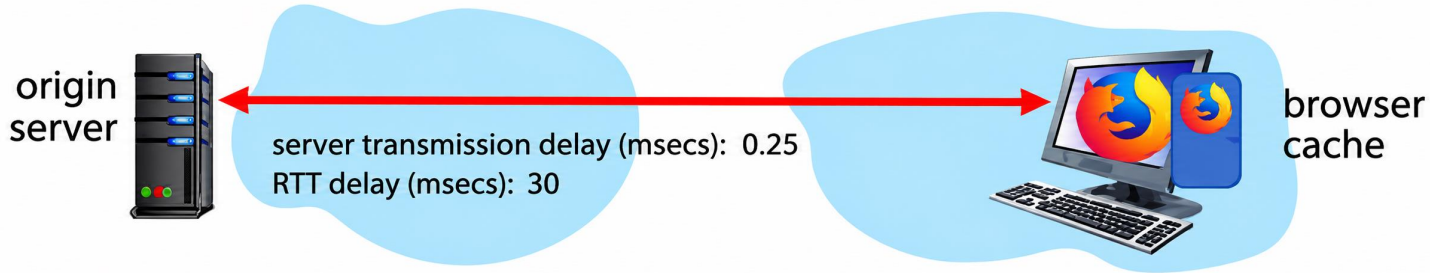


Exercise 3: Browser Caching

Every one of the 100 requests still needs one RTT, because the browser has to ask the server whether the cached object has changed. So: 100*30ms = 3000 ms.

For the 50% that have not changed, the server does not resend the object, so there is no 0.25 ms object transmission time. For the other 50% that have changed, the object must be transmitted again: 50*0.25 ms = 12.5 ms.

Thus, the total time is: 3000+12.5 = 3012.5 ms.



Exercise 4: DNS and Name Resolution

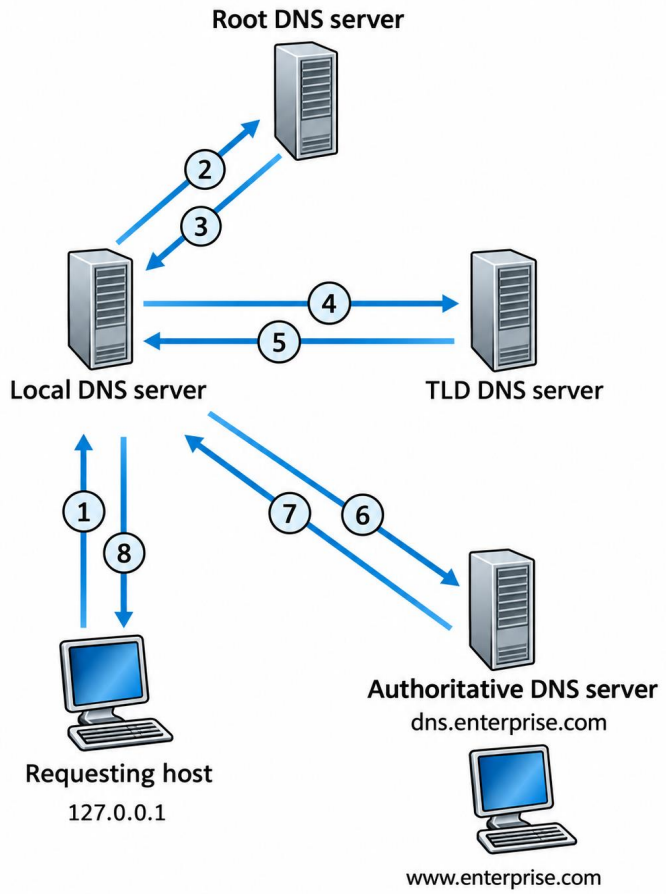
Suppose that you want to visit the website www.enterprise.com, but you do not know the IP address of the Web Server hosting it.

Assume that the TLD DNS Server contains the following records:

- (www.enterprise.com, dns.enterprise.com, NS)
- (dns.enterprise.com, 146.54.220.96, A)

Also, the enterprise.com DNS Server contains the following records

- (www.enterprise.com, west1.enterprise.com, CNAME)
- (west1.enterprise.com, 142.81.17.206, A)
- (enterprise.com, mail.enterprise.com, MX)
- (mail.enterprise.com, 247.29.199.104, A)



Exercise 4: DNS and Name Resolution

Answer the following questions:

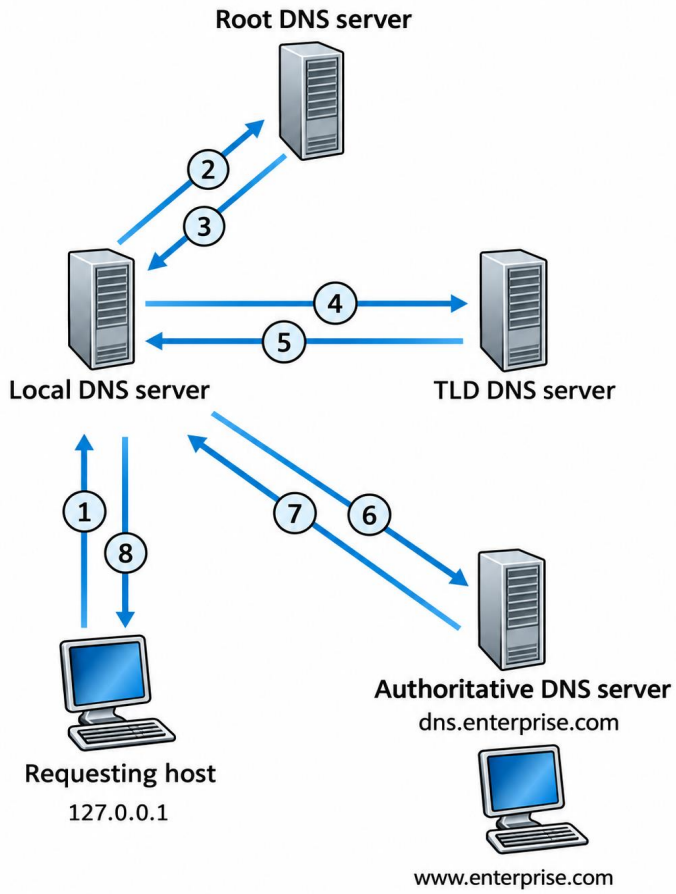
i. Which transport protocol does DNS use, and which well-known port does it use?

ii. In the aforementioned records, which different types of records (RRs-Resource Records) can you identify for enterprise.com, and what type of resource does each one specify?

iii. What is the name of the DNS server for this domain? What is the general name for a DNS server that is responsible for the RRs of a domain?

iv. If the website www.enterprise.com is hosted on the machine west1.enterprise.com, which type of record needs to be added?

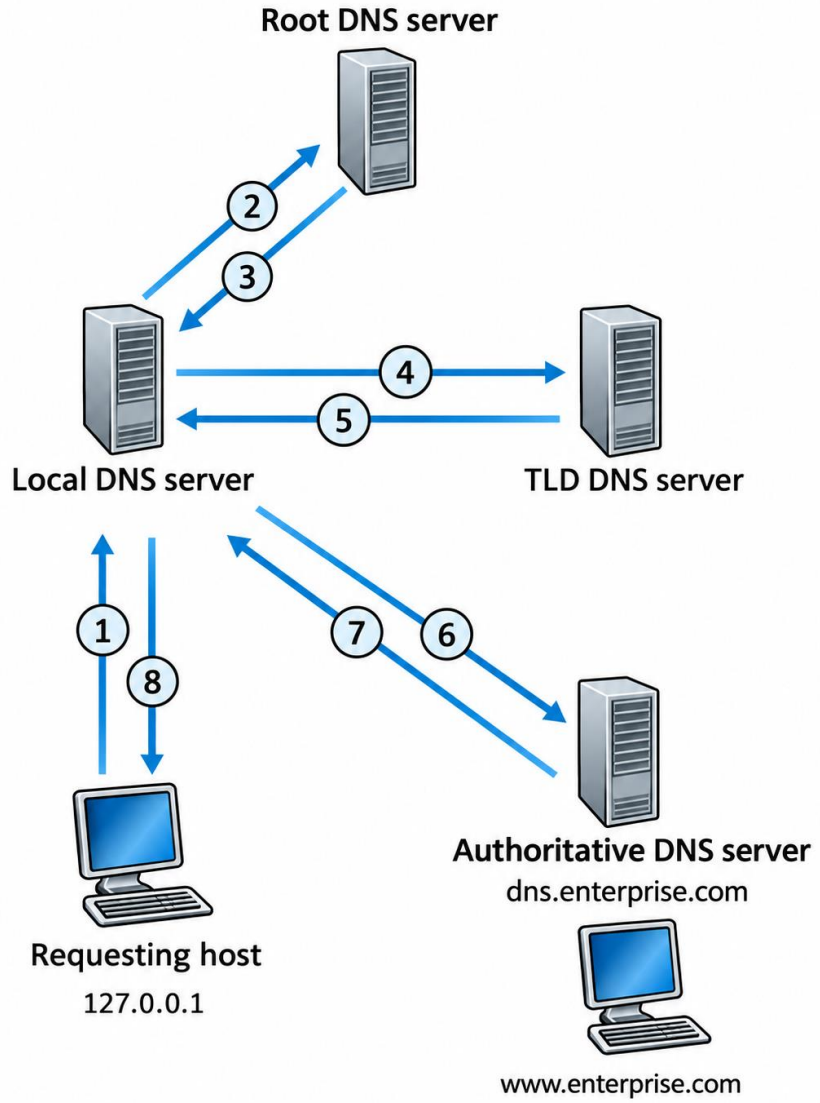
v. If we want to send an email message to admin@enterprise.com, which DNS record will we need?



Exercise 4: DNS and Name Resolution

i. Which transport protocol does DNS use, and which well-known port does it use?

DNS uses the UDP protocol, although in some cases, such as the transfer of the zone file, it may also use TCP. The well-known port for UDP is port 53.



Exercise 4: DNS and Name Resolution

ii. In the aforementioned records, which different types of records (RRs-Resource Records) can you identify for enterprise.com, and what type of resource does each one specify?

The records identified are:

NS: Name Server, specifies the DNS server for the domain,

A: Address, maps an IP address to a DNS name,

MX: Mail eXchanger, specifies the mail server that serves the domain

CNAME: Canonical Name, specifies an alternative (alias) name for a resource.

TLD DNS Server records:

- (www.enterprise.com, dns.enterprise.com, NS)
- (dns.enterprise.com, 146.54.220.96, A)

enterprise.com DNS Server records

- (www.enterprise.com, west1.enterprise.com, CNAME)
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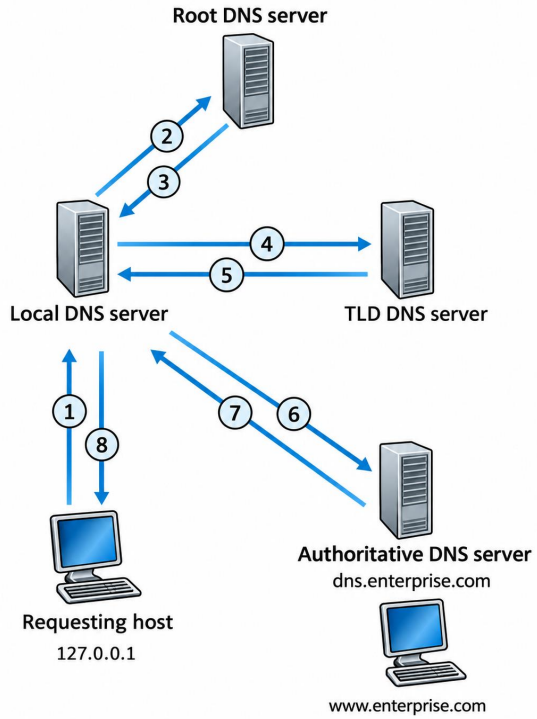
Exercise 4: DNS and Name Resolution

iii. What is the name of the DNS server for this domain? What is the general name for a DNS server that is responsible for the RRs of a domain?

The name of the DNS server is:

dns.enterprise.com.

The DNS server that is responsible for the RRs of a domain is called an authoritative DNS server.



TLD DNS Server records:

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- (dns.enterprise.com, 146.54.220.96, A)

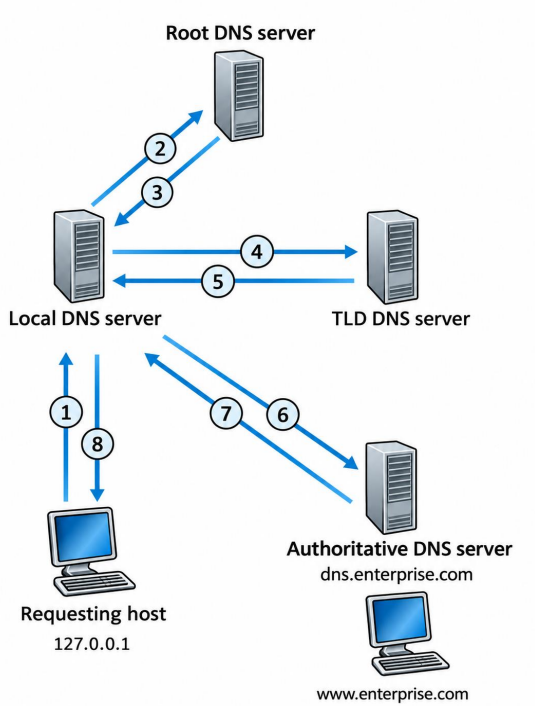
enterprise.com DNS Server records

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Exercise 4: DNS and Name Resolution

iv. If the website www.enterprise.com is hosted on the machine west1.enterprise.com, which type of record needs to be added?

A record of type CNAME needs to be added.



TLD DNS Server records:

- (www.enterprise.com, dns.enterprise.com, NS)
- (dns.enterprise.com, 146.54.220.96, A)

enterprise.com DNS Server records

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Exercise 4: DNS and Name Resolution

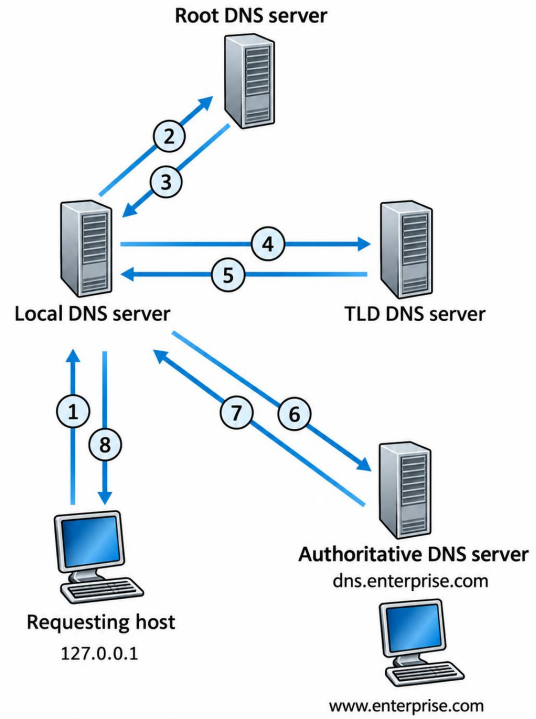
v. If we want to send an email message to admin@enterprise.com, which DNS record will we need?

We need the record that specifies the MX for the domain:

(enterprise.com, mail.enterprise.com, MX)

and then the record containing its IP address, so that we can communicate with it:

(mail.enterprise.com, 247.29.199.104, A)



TLD DNS Server records:

- (www.enterprise.com, dns.enterprise.com, NS)
- (dns.enterprise.com, 146.54.220.96, A)

enterprise.com DNS Server records

- (www.enterprise.com, west1.enterprise.com, CNAME)
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Exercise 5: HTTP Response

Consider the following communication in which a Web Server sends an HTTP Response message to a Web Browser. Assume that the HTTP REPLY message contains the following:

```
HTTP/1.1 404 Not Found
Date: Mon, 04 Dec 2017 21:10:25 +0000
Server: Apache/2.2.3 (CentOS)
Content-Length: 89069
Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
```

Exercise 5: HTTP Response

```
HTTP/1.1 404 Not Found
Date: Mon, 04 Dec 2017 21:10:25 +0000
Server: Apache/2.2.3 (CentOS)
Content-Length: 89069
Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
```

Answer the following questions:

i. Which version of HTTP is being used?
ii. Was the server able to successfully send the file? Explain.
iii. When was the response sent?
iv. How many bytes are in the file returned by the server?
v. What is the default connection type for the HTTP protocol? In this particular case, is the connection persistent or non-persistent? How can you tell?
vi. What type of file is being sent by the server?
vii. Which server software is being used?

Exercise 5: HTTP Response

i. Which version of HTTP is being used?

The server is using HTTP/1.1

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HTTP/1.1 404 Not Found
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Server: Apache/2.2.3 (CentOS)
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Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
```

Exercise 5: HTTP Response

ii. Was the server able to successfully send the file? Explain.

No. The server was not able to successfully send the requested file. The status code is 404 Not Found, which indicates that a problem occurred during the transfer

```
HTTP/1.1 404 Not Found
Date: Mon, 04 Dec 2017 21:10:25 +0000
Server: Apache/2.2.3 (CentOS)
Content-Length: 89069
Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
```

Exercise 5: HTTP Response

iii. When was the response sent?

The response was sent on: Mon, 04 Dec 2017 21:10:25 +0000, according to the server.

```
HTTP/1.1 404 Not Found
Date: Mon, 04 Dec 2017 21:10:25 +0000
Server: Apache/2.2.3 (CentOS)
Content-Length: 89069
Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
```

Exercise 5: HTTP Response

iv. How many bytes are in the file returned by the server?

The returned content has 89069 bytes.

```
HTTP/1.1 404 Not Found
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Content-Length: 89069
Keep-Alive: timeout=42, max=74
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Exercise 5: HTTP Response

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Server: Apache/2.2.3 (CentOS)
Content-Length: 89069
Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
```

v. What is the default connection type for the HTTP protocol? In this particular case, is the connection persistent or non-persistent? How can you tell?

The default connection mode for HTTP is persistent, because it improves protocol performance. Persistent connections generate less network traffic because they avoid the establishment and termination of multiple TCP connections. They reduce the waiting time for successive requests, since the TCP three-way handshake is avoided. The connections remain open long enough for TCP to identify the level of congestion and react accordingly. In this particular case, the connection is persistent (keep-alive).

Exercise 5: HTTP Response

vi. What type of file is being sent by the server?

The file type is image/html.

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Keep-Alive: timeout=42, max=74
Connection: Keep-alive
Content-type: image/html
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Exercise 5: HTTP Response

vii. Which server software is being used?

The server software is Apache/2.2.3.

```
HTTP/1.1 404 Not Found
Date: Mon, 04 Dec 2017 21:10:25 +0000
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Keep-Alive: timeout=42, max=74
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